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ABSTRACT

The plans for utilizing reusable space shuttles which could replace almost all present expendable launch vehicles are briefly described. Many illustrations are included showing the artists' concepts of various configurations proposed for space shuttles. (PR)

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SPACE SHUTTLE

SE 013 178

National
Aeronautics
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Administration

EP–77

Illustrations in this book consist of artists' concepts of various configurations proposed for the space shuttle system, which is expected to replace almost all present expendable launch vehicles. It will carry spacecraft into orbit for NASA, and for the U.S. Weather Bureau, the Department of Defense, and other Government agencies, the communications industry, foreign governments and other commercial users, and will return them to Earth for refurbishment and re-use.

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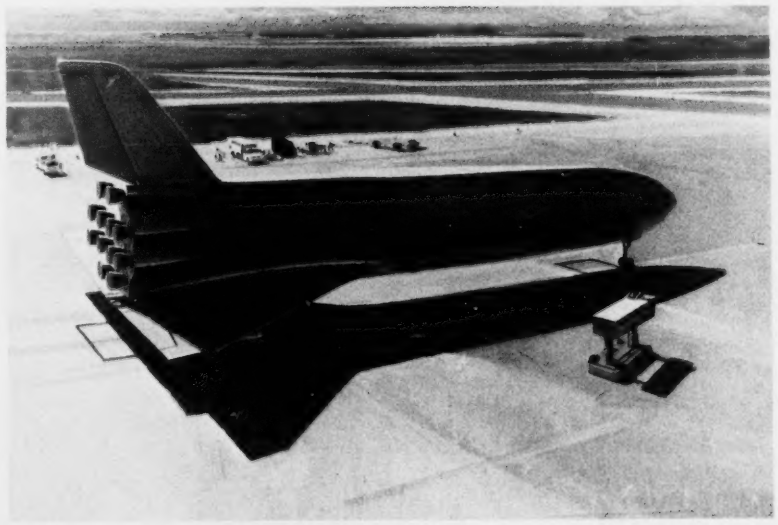
SPACE SHUTTLE

In the decade of the 1960's men learned how to leave their home planet and its atmosphere and to operate in space around the Earth and beyond. They walked on the Moon and sent automated observers to the near planets, scientific probes into deep space, and working satellites into Earth orbit.

The costs of space flight were reduced considerably in the first decade; but they are still high. They must come down much further if we are to realize the full promise of space. The costs are high because the launch vehicles and spacecraft are expended on each flight—as if we junked an automobile or an airplane after only one trip.

For the 1970's, NASA—in cooperation with other Government agencies, the aerospace industry, and the scientific community—is planning major improvements in the use of aircraft type space vehicles that can be operated at lower costs.

The key element in these plans is the reusable space shuttle, which will bring about economies both in transportation and in the cost of the spacecraft.



Rollout of a space shuttle booster element.

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SPACE FLIGHT COSTS

We have come a long way in the reduction of space transportation costs in the first dozen years of the space age.

The first U.S. satellite, Explorer I, weighing 30.8 pounds, was placed in orbit at a cost of more than $100,000 a pound. With the very large launch vehicles in use today we can deliver a useful payload into orbit at a cost of less than $1,000 a pound.

Further improvements in present vehicles can lead to additional cost reductions. But with the technology now available, there is the opportunity to do much better. The challenge of the 1970's is to make full use of the new technology that

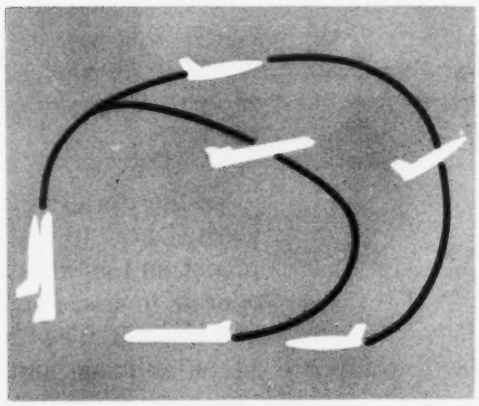
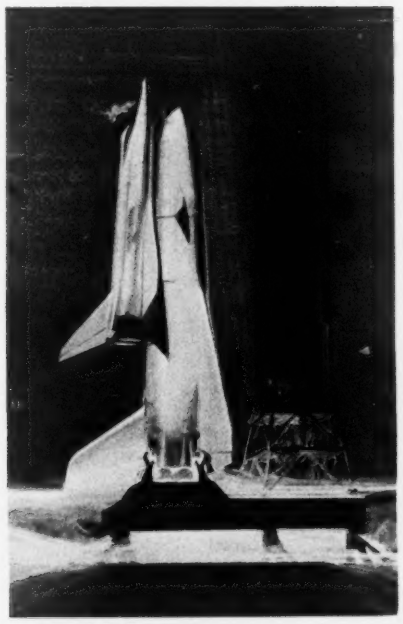
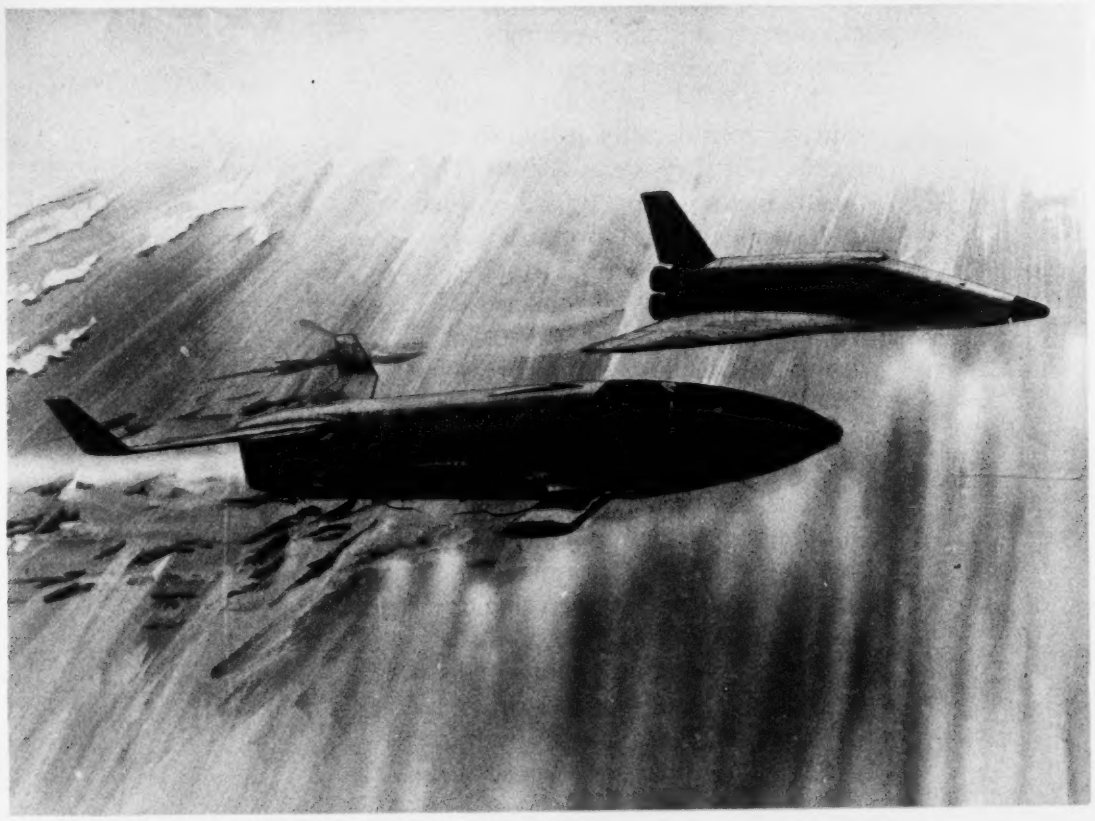


Diagram of the launch, separation and return to Earth of the space shuttle booster and orbiter.



Launch of a space shuttle vehicle.



Space shuttle orbiter separates from booster element.

was not on hand when the Saturn launch vehicle and the Apollo spacecraft were designed in the 1960's.

There are several opportunities for increasing the space program per-dollar output in the next decade. One is by integrated programming of manned and automated flight operations for maximum mutual support and using each type of operation where it will contribute the most to the overall product. Another is by maintaining a minimum number of kinds of vehicles to satisfy a maximum portion of space program needs.

Third and probably most important is the reusability of the same equipment over a long period and for a number of missions.

The space shuttle will be the first fully reusable space vehicle. With it, the transportation cost to orbit will be reduced to about a tenth of today's costs as a result of the use of this vehicle up to 100 times or more, and the fact that it will land on a jet-sized airstrip on land rather than at sea precludes the need for a recovery force of ships, airplanes, helicopters and frogmen.

The shuttle will also bring about major reductions in the costs of the satellites themselves. It will have as much internal space as large modern airliners. Thus it will be possible to use relatively inexpensive laboratory equipment in space, rather than space payloads highly miniaturized and extensively tested and checked out at great expense. In addition, the shuttle will be able to bring spacecraft back to Earth as easily as it puts them into orbit. Thus the equipment can be repaired, refurbished and used again.

The space shuttle will replace almost all present expendable launch vehicles. It will carry spacecraft into orbit for the U.S. Weather Bureau, the communications industry, the NASA space science and applications program and the Department of Defense. It will also take care of the future needs of commercial users, other Government agencies, and foreign governments. Later, it will carry passengers and cargo between the Earth and an orbiting space station or laboratory.

The orbiter injects spacecraft into orbit, and then returns to Earth.

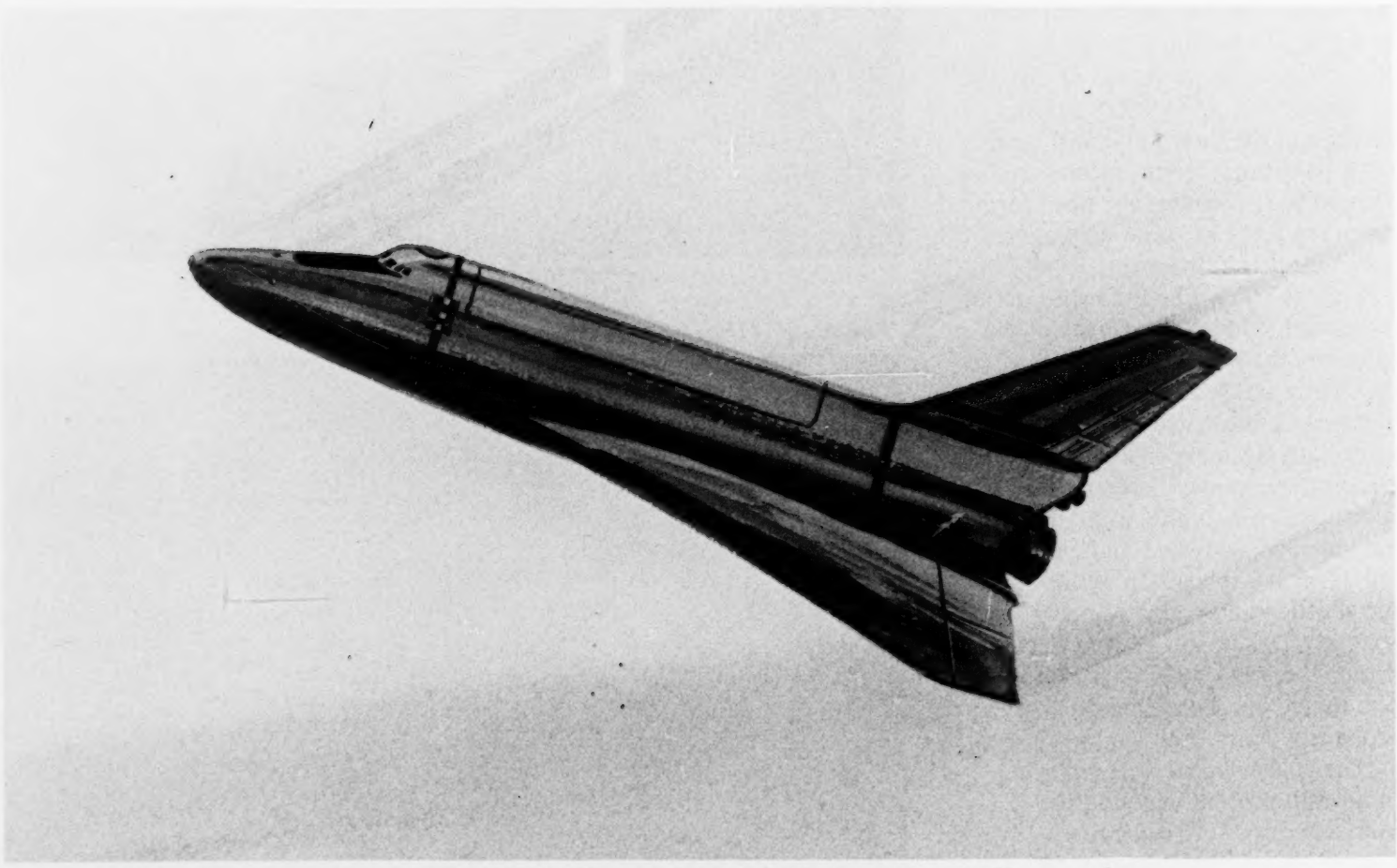
The shuttle orbiter checks out a spacecraft before injecting it into orbit.

REUSABLE VEHICLES

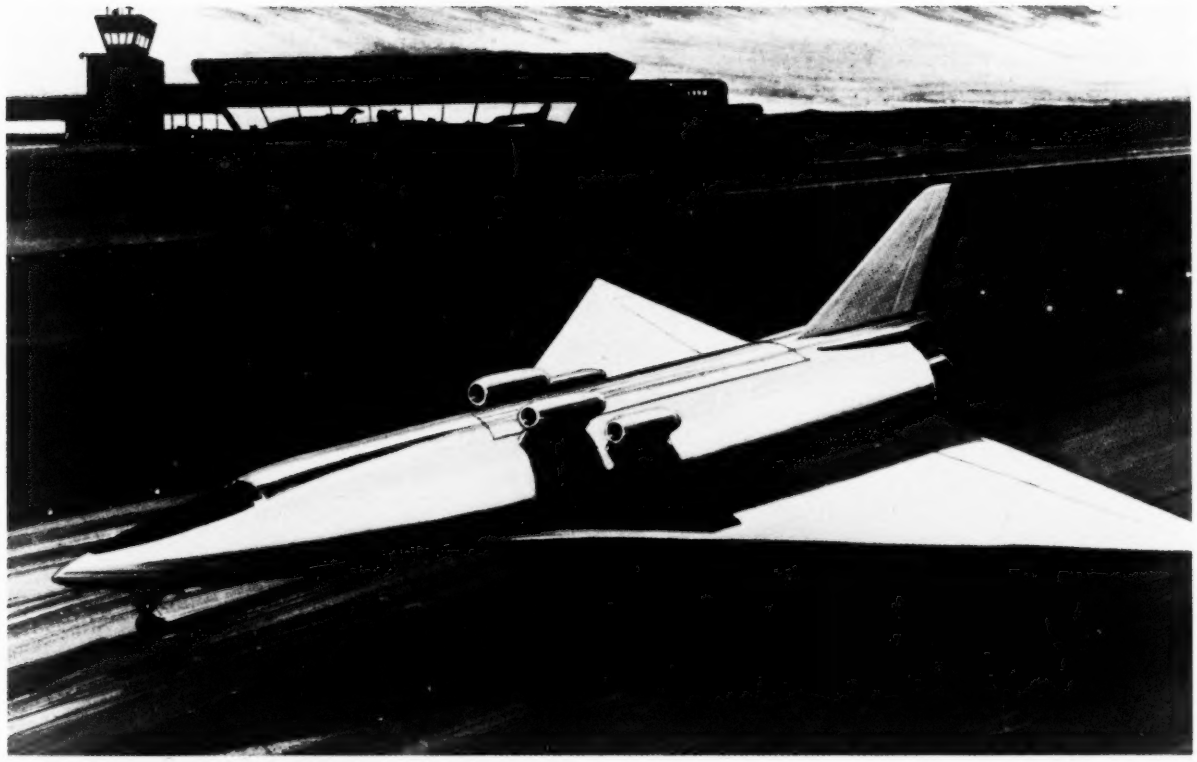
In planning the space shuttle the technologies of aeronautics and astronautics are being meshed to produce a new generation of space vehicles that would leave Earth as rockets and return as airplanes. The key feature of these space shuttles is that, like airliners, they would be flown repeatedly between Earth and space.

As currently planned, a typical space shuttle voyage would go something like this: The two-stage vehicle, an orbiter and a booster, would lift vertically from the launch pad. At an altitude of about 40 miles and a speed of about 8,000 miles an hour, the two stages would be separated and the booster would be piloted back to a horizontal landing on a regular airport runway. The engines of the orbiter would be ignited to speed it up to about 18,000 miles an hour to go into an orbit from 100 to 700 miles high.

After performing one of a number of potential missions, the orbiter would fire its rockets to slow down, enter the atmosphere, and be flown through the atmosphere to a selected airstrip on Earth, bringing back passengers, cargo, photographic film, magnetic tapes, and satellites or components for repair, replacement or re-use.



Orbiter element of space shuttle re-entering Earth's atmosphere.



Space shuttle landing at a conventional airport.

VEHICLE CONCEPTS

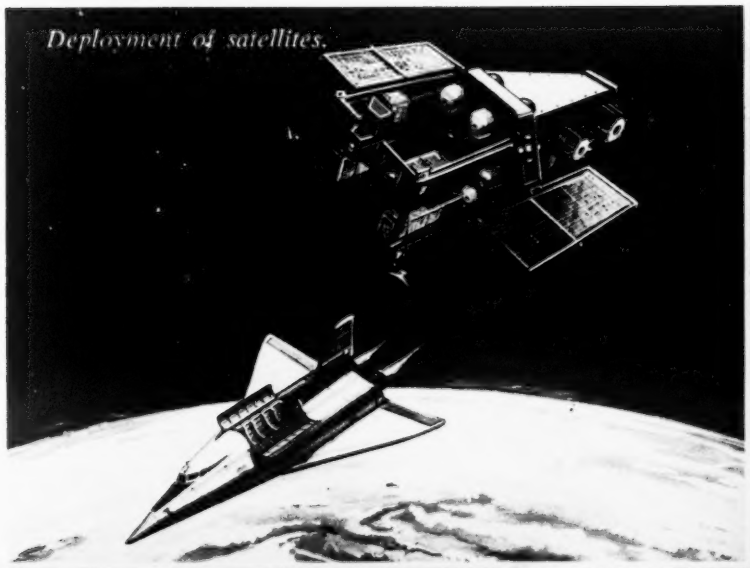
NASA and industry contractors are conducting definition studies of the two-stage, fully reusable concept of the space shuttle. The studies tend to confirm that this delta shaped concept is best. However, other candidate configurations are being studied and will be considered in the final decisions to proceed to actual design.

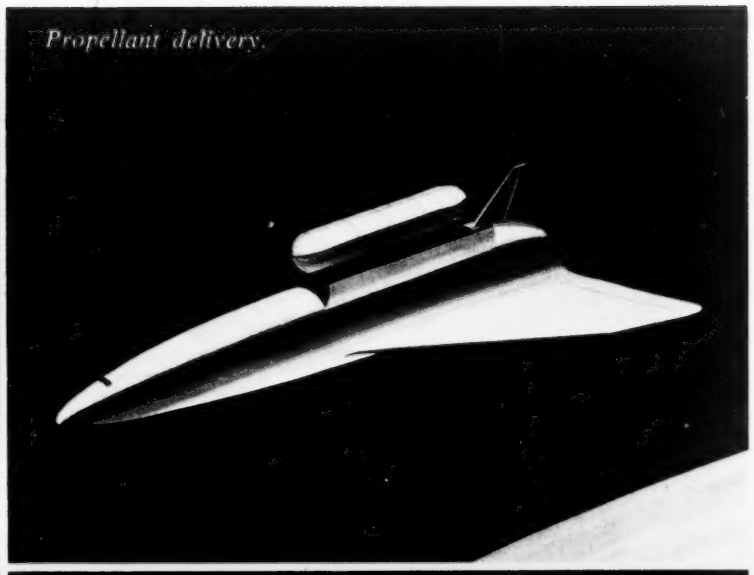
This delta (triangle) shaped vehicle has had much success in the nation's military flight programs. NASA's experimental lifting body program also has contributed to this concept. The lifting body which gets its gliding capabilities from its body shape and not from wings, has been demonstrated in tests at NASA's Flight Research Center in the California desert.

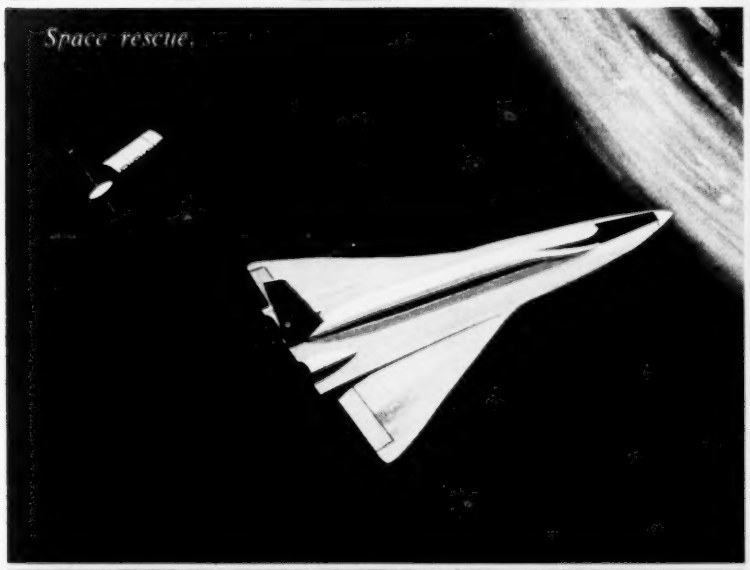
Development of the reusable shuttle calls for an extension of technology in some areas. One of these is the design of a lightweight aircraft structure with materials that can repeatedly withstand temperatures up to about 3,000 degrees Fahrenheit that may occur when entering the Earth's atmosphere.

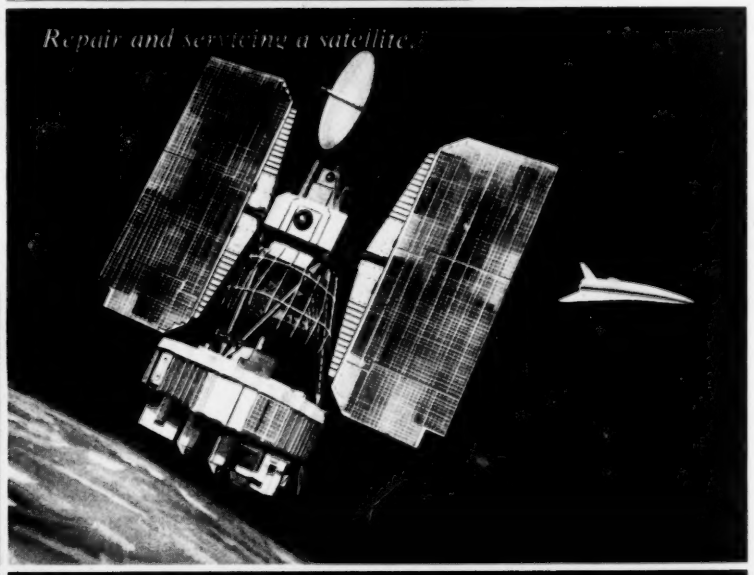
To meet the challenge of the reusable space shuttle, NASA and industry teams are investigating such aspects as structures, materials, vehicle dynamics, propulsion, electronics, and human factors as they might be applied to the space shuttle program. Preliminary configurations of space shuttle models are being tested in wind tunnels in several government research centers. Industry teams are studying possible engine and vehicle designs.

SPACE SHUTTLE MISSIONS

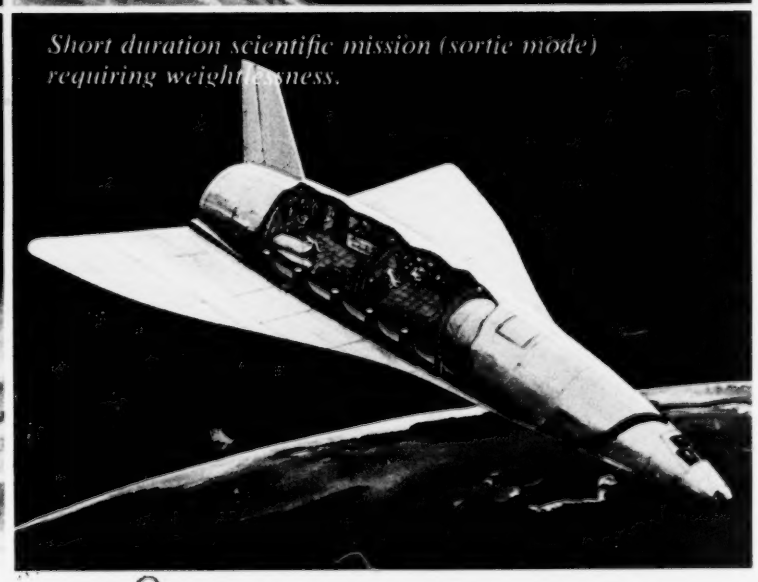

Deployment of satellites.


Propellant delivery.


Space rescue.


Repair and servicing a satellite.

Launching propulsive stage and satellite.


Short duration scientific mission (sortie mode) requiring weightlessness.

PERFORMANCE GOALS

NASA has drawn up a number of requisites for a reusable space shuttle system that will be the keystone for effective and economical space missions of the future. Among them are the following:

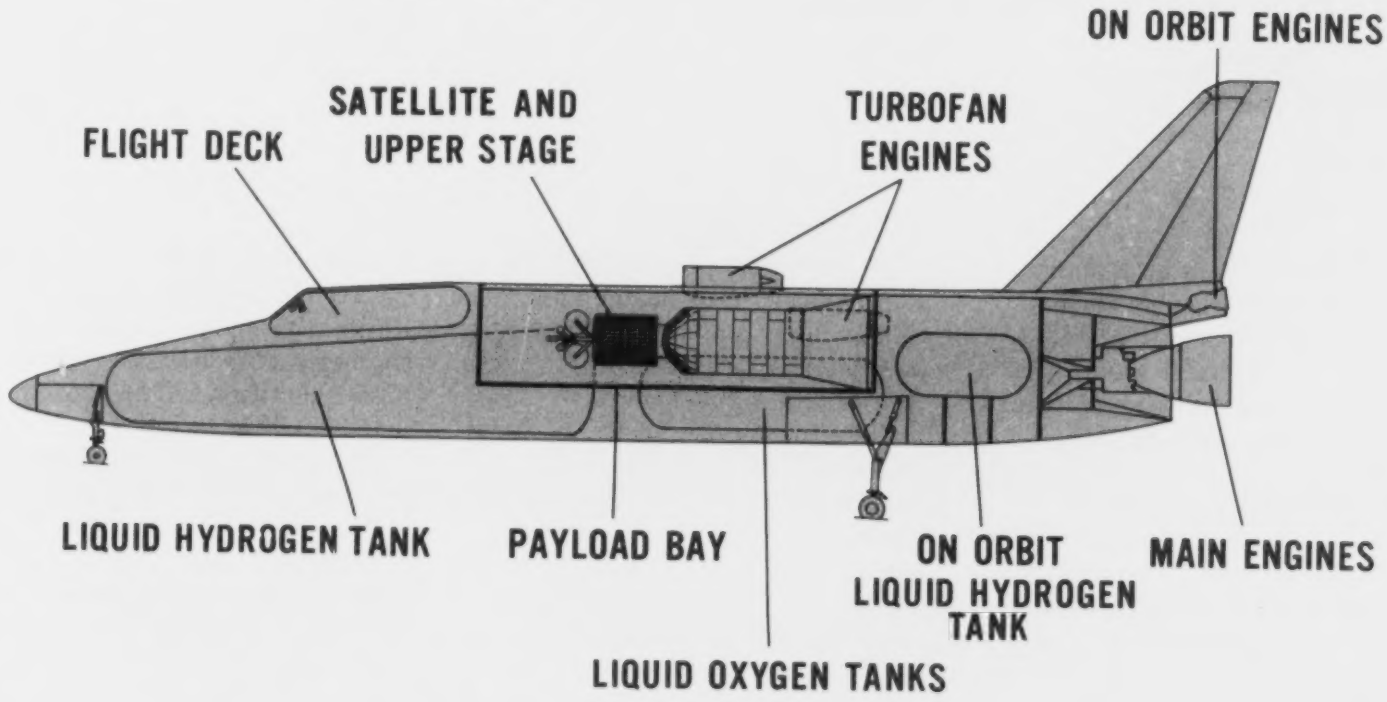
- To significantly reduce operational costs, the shuttle should have a life of about 100 missions with only minor refurbishment between flights. Postflight inspection, refurbishment, refueling, and takeoff procedures and progressive maintenance and overhaul programs comparable to those of scheduled jet airliners will be developed. Contributing to this goal will be on-board checkout largely independent of ground control.
- The interior of the space shuttle would be pressurized, enabling passengers and crew to ride in comfort without space suits. Takeoff and entry into the atmosphere would be relatively gentle, developing acceleration or deceleration forces on the occupants no higher than three times normal Earth gravity. Normally healthy passengers could easily withstand such a force.
- The craft would be built and equipped to land on a conventional runway about the length used by today's commercial jetliners. Turnaround time from landing to another launch should require approximately two weeks.
- Two crewmen may man each stage. The compartment for passengers or freight or a combination of the two will be cylindrical, 15 feet in diameter, and 60 feet long.
- The orbiter stage of the space shuttle will be designed for self-sustaining operation in Earth orbit for as long as a week.
- The rocket engines on both stages will be throttleable and require little more than refueling and minor refurbishment between missions. A number of high-performance engines powered by liquid hydrogen and liquid oxygen would be used for each stage. The booster is expected to have a cluster of 10 or more, the orbiter two or three. Each engine would be able to generate over 550,000 pounds of thrust at sea level conditions.
- Each stage may have conventional air-breathing jet engines for powered flight in the lower atmosphere.
- The first missions of the space shuttle will be to place in orbit and retrieve automated satellites.
- The shuttle will be able to deliver a payload of 65,000 pounds into a due-east orbit. Before landing, it will be able to turn and land 1100 miles to the right or the left of the orbital path.

During 1971 contractors are supporting the effort to define the space shuttle in detail and to establish a schedule for design and development.

Since the shuttle will be designed so that it can be maintained in a state of readiness for long periods, yet be launched within two hours notice, it would meet the need for a rescue system in the event of an emergency in space. If an Earth-orbiting space station or another shuttle became disabled, a rescue shuttle could be sent up to reach it within 24 hours.

The shuttle could also operate in the future as an emergency repair service for manned spacecraft, and could deliver urgently needed replacement parts for critical equipment such as a life-support system.

Cutaway view of the orbiter element.



LOOKING AHEAD

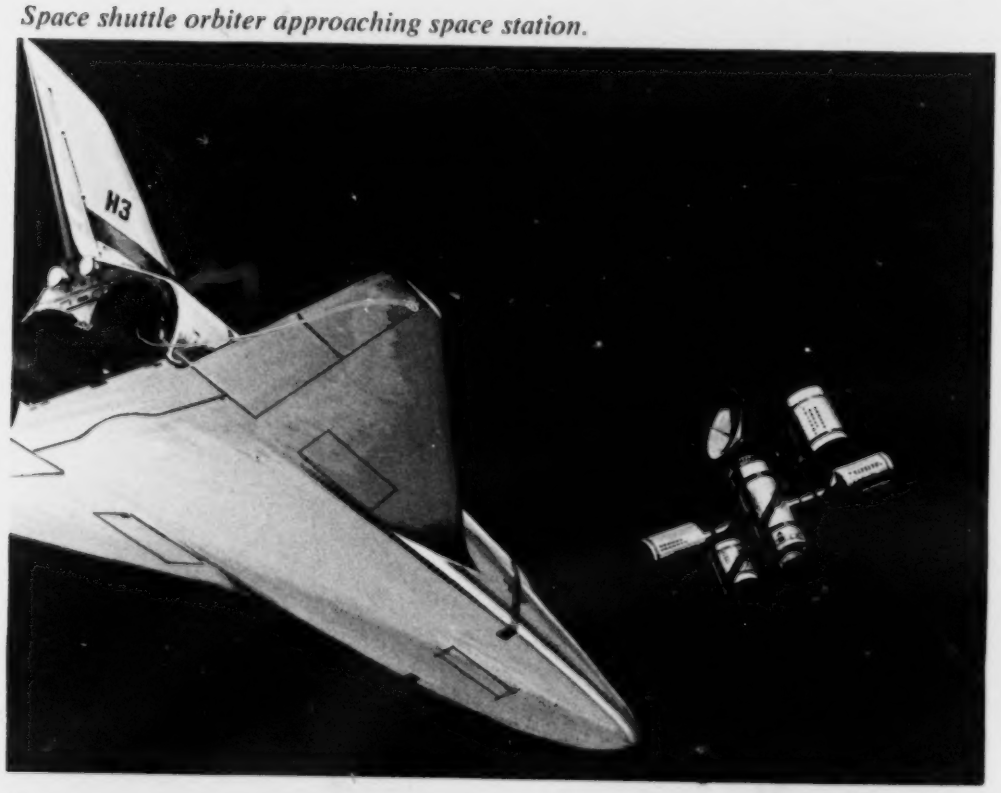
Reusable shuttles, making regular flights like commercial airliners, will carry satellites and space payloads for a number of U. S. and foreign government agencies, industrial companies and university scientists. Discussions are under way on arrangements by which other countries might participate in the space shuttle development.

With a shirt-sleeve cabin environment similar to that in today's commercial airliners, and with low gravity forces during launch and reentry, the space shuttle could carry passengers who are not trained astronauts and who do not necessarily meet the physical standards now required for space flight. They could be scientists, physicians, engineers, photographers, and other technicians—both men and women —of many organizations and many lands.

Ultimately, the space shuttle could become a part of a large transportation system that would extend the benefits of reusability to the nation's space program. The shuttle would carry passengers and freight to an Earth-orbiting space station where they would transfer to other vehicles for flights to the Moon and beyond.

Because of lowering the cost of transportation, and because of its flexibility, the shuttle will allow new, more efficient concepts to develop in communication systems in Earth orbit, data handling systems and large scale assemblies in space.

Space shuttle orbiter approaching space station.



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